

BULLETIN
OF THE
University of New Mexico
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GEOLOGICAL SERIES

MAY, 1929

VOL. IV. No. 1

**TABLES FOR DETERMINING
COMMON MINERALS AND ROCKS**



BY

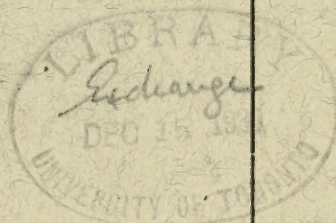
ROBERT W. ELLIS

PROFESSOR OF GEOLOGY IN THE UNIVERSITY OF NEW MEXICO

SECOND EDITION

ALBUQUERQUE, NEW MEXICO

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PREFACE

The following tables have been prepared to enable the student beginning geology to make a rapid and relatively accurate determination of some of the more common minerals and rocks. Many text-books of physical geology give but little attention to rocks and minerals. It seems important to the writer to base all geological study on a certain knowledge of the materials which make up the earth's surface and upon which the several dynamic processes have operated. An intelligent study of rocks involves at least an elementary knowledge of some minerals. Besides being an aid to the understanding of the principles of geology, a familiarity with the minerals and rocks of common occurrence is a desirable possession for many persons who have not had opportunity to take a course in geology. It is hoped that the outlines will be found useful to anyone who wishes to pursue the study of minerals and rocks at home.

In preparing the descriptive matter the writer has made free use of standard texts by Dana, Pirsson, Moses and Parsons, Rogers, Brush and Penfield, Kemp, Ries, etc.

In the revision of this text the same general purpose set forth for the first edition has been kept in view. The "Tables" have been in use for several years in geology classes at the University of New Mexico. The author is pleased to know that the manual has been found useful also by people not connected with these classes. The revision consists of a few corrections and changes in the descriptive matter of several minerals and the amplification of the glossary.

University of New Mexico
April 16, 1929.

R. W. E.

DETERMINING MINERALS AND ROCKS

A WORD TO THE STUDENT

In studying a specimen the student is cautioned against the impulse to hurry to a determination of the name of the mineral, or rock, without regard to detail in his observations. The most important mental acquirement in the process of the determination is the ability to make careful and complete observations. Every individual feature of the specimen should be noticed and briefly recorded. Time thus spent will also result in a more permanent retention of the characteristics of the specimen.

Ordinarily, the first noticeable feature of a mineral is its color. In the tables there are eight groups based on color. If there is doubt as to the color of the mineral it may be necessary to follow through color groups that grade into each other.

To determine the streak, the mineral is carefully drawn across the surface of unglazed porcelain, such as a floor tile or the edge of a broken dish. In case the mineral is too hard to make a mark, its streak may be found by powdering it finely and rubbing the powder on white paper.

The hardness of a mineral is the degree of resistance it offers to abrasion. As minerals vary much in hardness, a certain classification can be made on this property. The standard scale of hardness is as follows: Talc, 1; gypsum, 2; calcite, 3; fluorite, 4; apatite, 5; orthoclase, 6; quartz, 7; topaz, 8; corundum, 9; diamond, 10. Since the beginner can hardly be expected to be able to use this scale before he has learned the respective minerals named in it, a few common substances are suggested, with their approximate hardnesses: Lead (bullet or pipe), 1.5; thumb nail, 2.25; copper cent, 3; oyster shell, 3.5; steel nail, 4; pocket

knife, 5.25; window glass, 5.5; steel file, 6.25. A corner of the mineral should be drawn across the surface of the object whose hardness is known; if a permanent scratch is left, the mineral is the harder of the two materials. The test may also be made by attempting to scratch the given mineral by a corner of the hardness tester.

The degree of precision used will govern the outcome of subsequent procedure. A small error at one point may place you on the wrong track.

With the color, streak, and hardness determined, reference should be made to the descriptions of the minerals of the particular group. The numbers following the names of minerals in the classification correspond with numbers in the succeeding descriptions.

A similar plan is arranged for the determination of rocks. It will be found more difficult to determine rocks than minerals, since many rocks grade into one another and their descriptions can not be made so distinct. A field determination is preferable to the study of a hand specimen, as the relations and structural features are there more readily observed.

Very simple apparatus will suffice for most determinations. The student should have a pocket lens, and for collecting material a square-faced hammer is desirable. If hydrochloric (muriatic) acid is not at hand, strong vinegar may be used for testing carbonates.

GENERAL CLASSIFICATION OF MINERALS

I. WHITE OR COLORLESS

A. STREAK WHITE OR GRAY

HARDNESS—1.		HARDNESS—4.5	
Carnallite	16	Calamine	46
Talc	55	Colemanite	60
Bentonite	57	Magnesite	29
HARDNESS—1.5		HARDNESS—5.	
Talc	55	Smithsonite	31
Gypsum	63	Apatite	46
HARDNESS—2.		Calamine	58
Muscovite	49	Pyroxene	39
Kaolinite	56	HARDNESS—5.5	
Gypsum	63	Opal	18
Sylvite	14	Leucite	37
Clinocllore	53	Nephelite	38
HARDNESS—2.5		Pyroxene	39
Halite	13	Tremolite	41
Muscovite	49	HARDNESS—6.	
Lepidolite	50	Opal	18
Barite	61	Cassiterite	23
Clinocllore	53	Orthoclase	34
Kaolinite	56	Albite	36
HARDNESS—3.		Leucite	37
Calcite	27	Nephelite	38
Barite	61	Pyroxene	39
Anhydrite	62	Microcline	35
Lepidolite	50	HARDNESS—6.5	
HARDNESS—3.5		Opal	18
Sphalerite	8	Cassiterite	23
Dolomite	28	Albite	36
Lepidolite	50	Garnet	43
Barite	61	HARDNESS—7.	
Anhydrite	62	Quartz	17
Magnesite	29	Cassiterite	23
Siderite	30	Garnet	43
HARDNESS—4.		HARDNESS—7.5	
Sphalerite	8	Beryl	42
Fluorite	15	HARDNESS—8.	
Dolomite	28	Topaz	45
Lepidolite	50	Beryl	42
Colemanite	60	HARDNESS—9.	
Magnesite	29	Corundum	20
Siderite	30		

II. YELLOW

A. STREAK WHITE OR GRAY

HARDNESS—1.		Serpentine -----		54
Bauxite -----	26	HARDNESS—4.5		
Bentonite -----	57	Calamine -----	46	
HARDNESS—1.5		HARDNESS—5.		
Sulphur -----	2	Calamine -----	46	
Bauxite -----	26	Apatite -----	58	
Gypsum -----	63	HARDNESS—5.5		
HARDNESS—2.		Opal -----	18	
Sulphur -----	2	Nephelite -----	38	
Bauxite -----	26	HARDNESS—6.		
Clinochlore -----	53	Opal -----	18	
Gypsum -----	63	Cassiterite -----	23	
Kaolinite -----	55	Orthoclase -----	34	
HARDNESS—2.5		Nephelite -----	38	
Sulphur -----	2	Microcline -----	35	
Halite -----	13	HARDNESS—6.5		
Bauxite -----	26	Opal -----	18	
Clinochlore -----	53	Cassiterite -----	23	
Biotite -----	51	Garnet -----	43	
Serpentine -----	54	HARDNESS—7.		
Barite -----	61	Quartz -----	17	
Kaolinite -----	56	Cassiterite -----	23	
HARDNESS—3.		Garnet -----	43	
Bauxite -----	26	Staurolite -----	48	
Calcite -----	27	HARDNESS—7.5		
Biotite -----	51	Garnet -----	43	
Serpentine -----	54	Staurolite -----	48	
Barite -----	61	Beryl -----	42	
HARDNESS—3.5		HARDNESS—8.		
Sphalerite -----	6	Beryl -----	42	
Serpentine -----	54	Topaz -----	45	
Barite -----	61	HARDNESS—9.		
HARDNESS—4.		Corundum -----	20	
Sphalerite -----	8			
Fluorite -----	15			
Siderite -----	30			

B. STREAK YELLOW

HARDNESS—1.		HARDNESS—1.5	
Bauxite -----	26	Bauxite -----	26

HARDNESS—2.	
Bauxite	26
Kaolinite	56
Sulphur	2

HARDNESS—2.5	
Gold	3
Copper	4
Bauxite	26
Kaolinite	56
Sulphur	2

HARDNESS—3.	
Copper	4
Bauxite	26

HARDNESS—3.5	
Sphalerite	8
Magnesite	29

HARDNESS—4.	
Sphalerite	8
Magnesite	29

HARDNESS—4.5	
Magnesite	29

HARDNESS—5.	
Limonite	25

HARDNESS—5.5	
Limonite	25

C. STREAK GREEN

HARDNESS—3.5	
Chalcopyrite	10

HARDNESS—4.	
Chalcopyrite	10

HARDNESS—6.	
Pyrite	11
Marcasite	12

D. STREAK BLACK OR BROWN

HARDNESS—1-3	
Bauxite	26

HARDNESS—3.5-4.	
Sphalerite	8
Chalcopyrite	10

HARDNESS—5-5.5	
Limonite	25

HARDNESS—6-6.5	
Pyrite	11
Marcasite	12
Cassiterite	23

HARDNESS —7.	
Cassiterite	23

III. RED OR PINK

A. STREAK WHITE OR GRAY

HARDNESS—1.	
Carnallite	16

HARDNESS—1.5	
Gypsum	62

HARDNESS—2.	
Muscovite	49
Gypsum	63

HARDNESS—2.5	
Halite	13
Muscovite	49
Lepidolite	50
Biotite	51
Serpentine	54
Barite	61

HARDNESS—3.		Nephelite -----	38
Lepidolite -----	50	Microlite -----	35
Barite -----	61		
Anhydrite -----	62	HARDNESS—6.5	
		Opal -----	18
HARDNESS—3.5		Garnet -----	43
Dolomite -----	28	Chrysolite -----	44
Siderite -----	30		
Lepidolite -----	50	HARDNESS—7.	
Barite -----	61	Quartz -----	17
Anhydrite -----	62	Garnet -----	43
		Chrysolite -----	44
HARDNESS—4.		Tourmaline -----	47
Fluorite -----	15	Staurolite -----	48
Dolomite -----	28		
Siderite -----	30	HARDNESS—7.5	
Lepidolite -----	50	Beryl -----	42
		Garnet -----	43
HARDNESS—5.		Tourmaline -----	47
Apatite -----	58	Staurolite -----	48
HARDNESS—5.5		HARDNESS—8.	
Opal -----	18	Beryl -----	42
		Topaz -----	45
HARDNESS—6.			
Opal -----	18	HARDNESS—9.	
Orthoclase -----	34	Corundum -----	20

B. STREAK RED

HARDNESS—1.		Copper -----	4
Bentonite -----	57		
HARDNESS—1-2.		HARDNESS—3.5-4.	
Some earthy varieties of		Cuprite -----	19
hematite -----	21		
Bauxite -----	26	HARDNESS—5-6.5	
		Hematite -----	21
HARDNESS—2.5-3			
Bauxite -----	26		

C. STREAK BROWN

HARDNESS—2-2.5		Cuprite -----	19
Kaolinite -----	56		
HARDNESS—2.5-3.		HARDNESS—5-6.5.	
Copper -----	4	Hematite -----	21
		HARDNESS—6.5-7.	
		Cassiterite -----	23

IV. BROWN

A. STREAK WHITE OR GRAY

		Calamine -----	46
	HARDNESS—1.5.		
Sulphur -----	2		
		HARDNESS—5.	
	HARDNESS—2.	Smithsonite -----	31
Sulphur -----	2	Pyroxene -----	39
Muscovite -----	49	Hornblende -----	40
Biotite -----	51	Calamine -----	46
		Apatite -----	58
	HARDNESS—2.5		
Muscovite -----	49		
Biotite -----	51	HARDNESS—5.5.	
Barite -----	61	Opal -----	18
		Pyroxene -----	37
		Hornblende -----	40
	HARDNESS—3.		
Calcite -----	27		
Biotite -----	51	HARDNESS—6.	
Barite -----	61	Opal -----	18
		Pyroxene -----	39
		Hornblende -----	40
	HARDNESS—3.5.		
Sphalerite -----	8		
Dolomite -----	28	HARDNESS—6.5	
Magnesite -----	29	Opal -----	18
Siderite -----	30	Garnet -----	43
Barite -----	61	Chrysolite -----	44
	HARDNESS—4.		
Sphalerite -----	8		
Fluorite -----	15	HARDNESS—7.	
Dolomite -----	28	Quartz -----	17
Magnesite -----	29	Garnet -----	43
Siderite -----	30	Staurolite -----	48
	HARDNESS—4.5		
Magnesite -----	29	HARDNESS—7.5	
		Staurolite -----	48
		HARDNESS—9.	
		Corundum -----	20

B. STREAK YELLOW

	HARDNESS—2-2.5		
Kaolinite -----	56		
		HARDNESS—4.	
	HARDNESS—3.	Sphalerite -----	8
Calcite -----	27	Siderite -----	30
	HARDNESS—3.5		
Sphalerite -----	8	HARDNESS—5-5.5.	
Dolomite -----	28	Limonite -----	25
		HARDNESS—6.5-7.	
		Chrysolite -----	44

C. STREAK BROWN

HARDNESS—1-1.5.		Cuprite -----		19
Bauxite -----	26	HARDNESS—4.		
HARDNESS—2-2.5		Sphalerite -----	8	
Bauxite -----	26	Siderite -----	30	
Kaolinite -----	56	HARDNESS—5-5.5.		
HARDNESS—3.		Limonite -----	25	
Bornite -----	9	HARDNESS—6-6.5.		
Bauxite -----	26	Cassiterite -----	23	
HARDNESS—3.5.				
Sphalerite -----	8			

D. STREAK RED

HARDNESS—5-6.5.	
Hematite -----	21

E. STREAK WHITE OR GRAY

HARDNESS—3.		HARDNESS—7-7.5.	
Bornite -----	9	Staurolite -----	48

V. BLACK

A. STREAK WHITE OR GRAY

HARDNESS—1-1.5.		Hornblende -----		40
Graphite -----	1	HARDNESS—6.		
HARDNESS—2.		Cassiterite -----	23	
Graphite -----	2	Pyroxene -----	39	
Argentite -----	6	Hornblende -----	40	
Pyrolusite -----	24	HARDNESS—6.5.		
HARDNESS—2.5.		Cassiterite -----	23	
Galena -----	5	Garnet -----	43	
Argentite -----	6	HARDNESS—7.		
Chalcocite -----	7	Quartz -----	17	
Biotite -----	51	Garnet -----	43	
HARDNESS—3.		Cassiterite -----	23	
Chalcocite -----	7	Tourmaline -----	47	
Calcite -----	27	Staurolite -----	48	
Biotite -----	51	HARDNESS—7.5.		
HARDNESS—3.5-4.		Garnet -----	43	
Dolomite -----	28	Tourmaline -----	47	
HARDNESS—5-5.5.		Staurolite -----	48	
Pyroxene -----	39			

B. STREAK GREEN

HARDNESS—5-6.		Hornblende	40
Pyroxene -----	39		

C. STREAK YELLOW

HARDNESS—3.5-4.		HARDNESS—5-5.5.	
Sphalerite -----	8	Limonite -----	25

D. STREAK BROWN

HARDNESS—3-3.5.		Limonite -----	25
Sphalerite -----	8		
HARDNESS—5-5.5.		HARDNESS—6-7.	
		Cassiterite -----	23

E. STREAK RED

HARDNESS—5-6.5.	
Hematite -----	21

F. STREAK BLACK OR DARK GRAY

HARDNESS—1-1.5.		Pyrolusite -----	24
Graphite -----	1		
HARDNESS—2.		HARDNESS—3.	
Argentite -----	6	Chalcocite -----	7
Pyrolusite -----	24	Bornite -----	9
HARDNESS—2.5.		HARDNESS—5.5-6.5.	
Galena -----	5	Magnetite -----	22
Argentite -----	6		
Chalcocite -----	7	HARDNESS—7-7.5.	
		Tourmaline -----	47

VI. GRAY

A. STREAK GRAY

HARDNESS—1-1.5.		Argentite -----	6
Graphite -----	1	Chalcocite -----	7
		Pyrolusite -----	24
HARDNESS—2.		HARDNESS—3.	
Graphite -----	1	Chalcocite -----	7
Argentite -----	6		
Pyrolusite -----	24	HARDNESS—6-6.5.	
HARDNESS—2.5.		Marcasite -----	12
Galena -----	5		

B. STREAK WHITE

HARDNESS—1		HARDNESS—4.5.	
Bauxite	26	Magnesite	29
Talc	55	Colemanite	60
HARDNESS—1.5.		HARDNESS—5.	
Sulphur	2	Smithsonite	31
Bauxite	26	Pyroxene	39
Gypsum	63	Hornblende	40
Talc	55	Apatite	58
HARDNESS—2.		HARDNESS—5.5.	
Sulphur	2	Opal	18
Bauxite	26	Leucite	37
Muscovite	49	Nephelite	38
Lepidolite	50	Pyroxene	39
Kaolinite	56	Hornblende	40
		Tremolite	41
HARDNESS—2.5.		HARDNESS—6.	
Sulphur	2	Opal	18
Bauxite	26	Cassiterite	23
Muscovite	49	Orthoclase	34
Lepidolite	50	Albite	36
Serpentine	54	Leucite	37
Kaolinite	56	Nephelite	38
Barite	61	Pyroxene	39
		Hornblende	40
HARDNESS—3.		HARDNESS—6.5.	
Bauxite	26	Opal	18
Calcite	27	Cassiterite	23
Lepidolite	50	Albite	36
Serpentine	54		
Barite	61		
Anhydrite	62		
HARDNESS—3.5.		HARDNESS—7.	
Dolomite	28	Cassiterite	23
Magnesite	29		
Siderite	30	HARDNESS—7.5.	
Lepidolite	50	Beryl	42
Serpentine	54		
Barite	61	HARDNESS—8.	
Anhydrite	62	Beryl	42
		Topaz	45
HARDNESS—4.		HARDNESS—9.	
Dolomite	28	Corundum	20
Magnesite	29		
Siderite	30		
Lepidolite	50		
Serpentine	54		
Colemanite	60		

C. STREAK BROWN

HARDNESS—6-6.5.

Marcasite 12

D. STREAK RED

HARDNESS—5-6.5.

Hematite 21

E. STREAK BLACK

HARDNESS—1-1.5.

Graphite	1	Argentite	6
		Chalcocite	7
		Pyrolusite	24

HARDNESS—2.

Graphite	1	HARDNESS—3.	
Argentite	6	Chalcocite	7
Pyrolusite	24		

HARDNESS—2.5.

Galena	5	HARDNESS—6-6.5.	
		Marcasite	12

VII. GREEN

A. STREAK WHITE OR GRAY

HARDNESS—1-1.5.

Prochlorite	52	Siderite	30
Talc	55	Serpentine	54

HARDNESS—2.

Muscovite	49	Calamine	46
Prochlorite	52		
Clinochlore	53	HARDNESS—5.	

HARDNESS—2.5.

Muscovite	49	Smithsonite	31
Biotite	51	Pyroxene	39
Clinochlore	53	Hornblende	40
Serpentine	54	Calamine	46
		Apatite	58
		Turquoise	59

HARDNESS—3.

Calcite	27	Opal	18
Biotite	51	Nephelite	38
Serpentine	54	Pyroxene	39
		Hornblende	40
		Turquoise	59

HARDNESS—3.5.

Dolomite	28	HARDNESS—6.	
Serpentine	54	Opal	18

HARDNESS—4.

Fluorite	15	Orthoclase	34
Dolomite	28	Albite	36
		Nephelite	38
		Pyroxene	39

Hornblende -----	40	Garnet -----	43
Turquoise -----	59	Chrysolite -----	44
Microcline -----	35	Tourmaline -----	47

HARDNESS—6.5.

Opal -----	18
Albite -----	36
Garnet -----	43
Chrysolite -----	44

HARDNESS—7.5.

Beryl -----	42
Garnet -----	43
Tourmaline -----	47

HARDNESS—7.

Quartz -----	17
--------------	----

HARDNESS—8.

Beryl -----	42
Topaz -----	45

B. STREAK GREEN

HARDNESS—1-1.5.

Prochlorite -----	52
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HARDNESS—2.

Prochlorite -----	52
Clinochlore -----	53

HARDNESS—2.5.

Clinochlore -----	53
-------------------	----

HARDNESS—3.5.-4.

Malachite -----	32
-----------------	----

HARDNESS—5-6.

Pyroxene -----	39
Hornblende -----	40
Turquoise -----	59

VIII. BLUE OR VIOLET

A. STREAK WHITE OR GRAY

HARDNESS—1.5.2.

Gypsum -----	63
--------------	----

HARDNESS—2.5.

Halite -----	13
Barite -----	61

HARDNESS—3.

Calcite -----	27
Barite -----	61
Anhydrite -----	62

HARDNESS—3.5.

Barite -----	61
Anhydrite -----	62

HARDNESS—4.

Fluorite -----	15
----------------	----

HARDNESS—4.5.

Calamine -----	46
----------------	----

HARDNESS—5.

Smithsonite -----	31
Calamine -----	46
Apatite -----	58
Turquoise -----	59

HARDNESS—5.5.

Opal -----	18
Nephelite -----	38
Turquoise -----	59

HARDNESS—6.

Opal -----	18
Albite -----	36
Nephelite -----	38
Turquoise -----	59

HARDNESS—6.5

Opal -----	18
Albite -----	36

HARDNESS—7.		HARDNESS—8.	
Quartz	17	Beryl	42
Tourmaline	47	Topaz	45
HARDNESS—7.5.		HARDNESS—9.	
Beryl	42	Corundum	20
Tourmaline	47		

B. STREAK BLUE

HARDNESS—2-2.5.		HARDNESS—3.5-4.	
Pyrolusite	24	Azurite	34

C. STREAK GREEN

HARDNESS—5-6.	
Turquoise	59

DESCRIPTION OF MINERALS

NATIVE ELEMENTS

1. *Graphite.*

Lead-black to steel-gray. Metallic luster. Greasy feel. Streak, lead-colored. $H.=$ less than 1, to 2, soiling the fingers. $G.=2.09-2.3$. Cleavage in one direction. Resembles molybdenite but is lower in specific gravity. Composition, carbon (C). Used for lead-pencils, lubricant, crucibles, stove polish. Occurs in metamorphic rocks, being often the result of metamorphism of coal beds. Also called plumbago or black lead.

2. *Sulphur.*

Yellow. Resinous luster. Brittle. White or pale yellow streak $H.=1.5-2.5$. $G.=2.05-2.09$. Burns with a blue flame and gives off a strong choking gas (sulphur dioxide.) Composition, sulphur (S), often with impurities. Used in the manufacture of sulphuric acid, in paper making, in making matches, gunpowder, insecticides, in vulcanizing rubber. Occurs in beds of gypsum and associated rocks; around volcanoes and mineral springs. In the United States, it is most abundant in Louisiana and Texas.

3. *Gold.*

Yellow. Metallic luster. Malleable. $H.=2.5-3$. $G.=15.6-19.3$. Streak, yellow. Composition, gold (Au), but usually alloyed with silver. The chief ore of gold. Occurs most commonly in quartz veins and in placer deposits.

4. *Copper.*

Copper-red. Metallic luster. Malleable. Streak like the color, and shining. $H.=2.5-3$. $G.=8.8-8.9$. Com-

position, copper (Cu), often with a little silver. An important ore of copper. Occurs usually as a secondary deposit. The most important region of its occurrence is the Keweenaw peninsula, Michigan.

SULPHIDES

5. *Galena*.

Lead-gray. Metallic luster. Streak, lead-gray. Cleavage, cubic, perfect. $H.=2.5-2.75$. $G.=7.4-7.6$. Composition, lead sulphide (PbS). The most important ore of lead. Widely distributed; occurs in Missouri, Wisconsin, and Illinois, associated with zinc sulphide. Also known as galenite and lead glance.

6. *Argentite*.

Dark lead-gray. Metallic luster. Sectile. Streak, lead-gray. $H.=2-2.5$. $G.=7.20-7.36$. Composition, silver sulphide (Ag_2S). An important ore of silver. Known also as silver glance.

7. *Chalcocite*.

Blackish lead-gray, often tarnished black. Metallic luster. Rather sectile. More brittle than argentite. $H.=2.5-3$. $G.=5.5-5.8$. Composition, cuprous sulphide (Cu_2S). An important ore of copper. Occurs usually as a secondary deposit in copper veins. Notable deposits at Butte, Montana; Clifton, Arizona; Copper River district, Alaska. Called copper glance, by miners.

8. *Sphalerite*.

Yellowish brown, black, brownish, or almost colorless. Luster, resinous to adamantine, or submetallic. Cleavage, dodecahedral, perfect. $H.=3.5-4$. $G.=3.9-4.1$. Streak, brownish to yellow or white. Composition, zinc sulphide (ZnS .) The most important ore of zinc. Occurs notably in southwestern Mis-

souri, associated with galena, marcasite, and calcite in limestone rocks. Called zinc blende or black jack.

9 *Bornite.*

Brownish bronze, purplish brown, iridescent tarnish. Brittle. Metallic luster. Streak, grayish black. Magnetic after heating. $H.=3$. $G.=4.9-5.4$. Composition copper-iron sulphide (Cu_5FeS_4). An ore of copper. Occurs as a primary mineral in igneous rocks or as a secondary deposit in veins.

10. *Chalcopyrite.*

Bright brass-yellow, often tarnished or iridescent. Metallic luster. Streak, greenish black. Brittle. $H.=3.5-4$. $G.=4.1-4.3$. The most important ore of copper. Commonly occurs as a primary deposit in veins; also is found in basic igneous rocks. Composition, a copper-iron sulphide ($CuFeS_2$). Called copper pyrites.

11. *Pyrite.*

Pale brass-yellow. Metallic luster. Streak, greenish black or brownish black. Brittle. $H.=6-6.5$. $G.=4.95-5.10$. Composition, iron disulphide (FeS_2). Not an iron ore, but is used mainly in the manufacture of sulphuric acid; often carries gold. It is of wide occurrence. Other names, iron pyrites, fool's gold.

12. *Marcasite.*

Pale brass-yellow, with a grayish to greenish tinge. Metallic luster. Fracture, rough. Brittle. It is paler than pyrite, and is more unstable. Common forms of occurrence are stalactitic, disc-shaped, etc., with a radiated structure; also crest-like and spear-head forms. $H.=6-6.5$. $G.=4.85-4.90$. Composition, iron disulphide (FeS_2). Occurs in coal beds and other sedimentary rocks, usually being a deposit from surface solutions rather than from deep-seated sources.

*HALOIDS, ETC.*13. *Halite*.

Colorless, white, often reddish or bluish. Cleavage, cubic. Form, in cubes, granular, or massive. Taste, salty. Luster, vitreous. $H.=2.5$. $G.=2.1-2.6$. Composition, sodium chloride ($NaCl$). A preservative, household uses; in the manufacture of soap and glass. Occurs in extensive beds, associated with gypsum, due to the evaporation of sea-water; in salt lakes and the ocean. Deposits, in New York, Michigan, Louisiana, Kansas, New Mexico, etc. Commonly called salt.

14. *Sylvite*.

Colorless or white. Cleavage, cubic. Taste, salty but bitter $H.=2$. $G.=1.99$. Composition, potassium chloride (KCl). Used as a fertilizer and a source of potash. Occurs in beds, associated with other soluble salts, at Stassfurt, Germany; in shallow lakes in western Nebraska.

15. *Fluorite*.

White, various tints of blue, green purple, or brown. Cleavage, good, in four directions, forming perfect octahedrons. $H.=4$. $G.=3.01-3.25$. Crystallizes in cubes, or in tufts or rosettes. Transparent to translucent. Streak white. Composition, calcium fluoride (CaF_2). Used as a flux in steel manufacture; in enameling; in making opalescent glass, and in preparing hydrofluoric acid. Occurs commonly as a vein deposit, associated with galena and sphalerite. Commercially known as fluor spar.

16. *Carnallite*.

White or colorless, often reddish. Taste, bitter. Deliquescent. $H.=1$. $G.=1.60$. Composition, hydrous potassium-magnesium chloride ($KMgCl_3 \cdot 6H_2O$). Used as fertilizer. Occurs in beds, at Stassfurt.

OXIDES

17. *Quartz.*

White to colorless; may be almost any color, owing to impurities. Luster, vitreous, sometimes greasy. $H.=7$. $G.=2.65-2.66$. Fracture, conchoidal to sub-conchoidal. Transparent to opaque. Insoluble in most acids. Composition, silicon dioxide (SiO_2). The crystal and colored forms, used as jewelry or ornaments; the prime constituent of sandstone and quartzite; an abrasive; for making glass; for concrete. Of very wide occurrence; as a constituent of granite and other igneous rocks; as the main component of sandstones and beds of sand and gravel; and as a gangue in mineral veins.

VARIETIES OF QUARTZ.

A. CRYSTALLIZED, WITH VITREOUS LUSTER.

a. Rock Crystal.

Colorless or clear. With, or without, crystal form.

b. Milky Quartz.

White, Nearly opaque. Luster, often greasy. Occurs commonly in veins and pegmatite dikes; the quartz of igneous rocks is commonly of this type.

c. Rose Quartz.

Pink or rose-colored. Occurs in pegmatite dikes, usually in rather large masses.

d. Amethyst.

Purplish or lavender-colored. Nearly transparent. Used as gem.

e. Smoky Quartz.

Smoky yellow to dark brown tinge. Nearly transparent in thin pieces.

f. Citrine.

Clear yellow. Called false topaz.

g. Cat's Eye.

Grayish brown or greenish. Opalescent.

B. NOT VISIBLY CRYSTALLIZED, HAVING A DULL OR WAXY LUSTER. NEVER CLEAR.

a. *Chalcedony*.

Pale blue, gray, or white, sometimes brownish. Occurs commonly as a lining to cavities in rocks.

b. *Agate*.

Colors in bands or layers, concentric or irregular, as having been deposited by water in rough cavities in rock.

c. *Moss Agate*.

Chalcedony containing moss-like figures of brown or black.

d. *Onyx*.

Colors in plane layers. A kind of agate.

e. *Flint*.

Smoky gray to nearly black. Fracture, broadly conchoidal. Formerly much used for weapons and implements. Occurs as nodules in chalk beds; also, in thin layers in some limestones; it is to this form that the term chert is probably more commonly applied.

f. *Jasper*.

Red, yellow, or brown; also greenish and bluish. Opaque.

18 *Opal*.

All colors or colorless; often a rich play of colors. Transparent or translucent. Luster, vitreous; sometimes resinous or pearly. $H.=5.5-6.5$. $G.=1.9-2.3$. Composition, hydrous silica ($SiO_2 \cdot nH_2O$). Some varieties are used as gems. Occurs as a deposit in seams and cavities in igneous rocks; also embedded in limestones and shales in concretion-like masses; deposited from the waters of hot springs; as deposits of diatomaceous earth and concretionary masses therein.

VARIETIES OF OPAL.

a. *Precious Opal*.

Shows play of colors.

b. *Fire Opal*.

Red to yellow, with flash of color on turning.

c. Common Opal.

Any color, but not a play of colors. Translucent to opaque.

d. Wood Opal.

Wood petrified by opal.

e. Hyalite.

Colorless. Like bunches of drops.

f. Geyserite.

White. Porous, concretionary deposits around geysers.

g. Diatomaceous Earth.

White. In masses or beds. Somewhat porous and friable. The remains of diatoms.

19. *Cuprite.*

Cochineal-red, various other shades of red. Streak, red. Luster, adamantine to submetallic. $H.=3.5-4$. $G.=5.85-6.15$. Not magnetic before or after heating. Composition, cuprous oxide (Cu_2O). A rich copper ore. A secondary deposit in the oxidized zone. Called red copper ore.

20. *Corundum.*

Bluish gray, brown, red, and other colors. $H.=9$. $G.=3.95-4.10$. Luster, adamantine to vitreous. Tough and difficult to break when in large masses. Has a property resembling cleavage. Composition, aluminum oxide (Al_2O_3). Some varieties are valuable for gems; formerly the common varieties were used as an abrasive. Occurs in certain igneous and metamorphic rocks.

VARIETIES OF CORUNDUM.

a. Corundum.

The common, massive variety.

b. Emery.

Granular, containing magnetite or hematite.

c. Sapphire.

Blue. Transparent to translucent. A gem.

d. Ruby.

Red. Transparent to translucent. A gem; some specimens, more valuable than the diamond.

21. *Hematite.*

Cherry-red, reddish brown, dark steel-gray, or black. Streak, red or reddish brown. Magnetic after heating, but not before. Luster, metallic to dull. Various forms—fibrous and splintery, oolitic, scale-like, massive, and earthy. $H.=5-6.5$. $G.=4.9-5.3$. Earthy forms show a lower degree of hardness. Composition, ferric oxide (Fe_2O_3). The most important iron ore; also used in paints. Widely distributed, and in rocks of all geological ages; the most important locality in the United States is the Lake Superior region; Alabama, near Birmingham, is a notable producer.

VARIETIES OF HEMATITE.

a. Red Hematite.

Red to brownish red. Massive to earthy. The Mesabi range, Minnesota, produces this type.

b. Specular Iron.

Steel-gray or black. Luster, metallic and glistening. In crystals or as scale-like masses.

c. Oolitic.

Red. Masses composed of rounded grains and particles resembling fragments of shells. Called, also, Clinton iron ore; Alabama ores, of this type.

22. *Magnetite.*

Black. Magnetic, Streak, black. Luster, metallic to dull. $H.=5.5-6.5$. $G.=5.1-5.2$. Composition, ferrous-ferric oxide (Fe_3O_4). Important ore of iron.

23. *Cassiterite.*

Brown or black. $H.=6.7$. $G.=6.8-7.1$. Luster, adamantine. In masses or grains. Composition, tin

oxide (SnO_2). The most common ore of tin. Occurs in sands and gravels; most commonly occurs in veins in granites.

24. *Pyrolusite*.

Black, steel-gray, bluish. Streak, black. $H.=1-2.5$. $G.=4.73-4.86$. Often soft enough to soil the fingers. Fibrous and columnar forms, common; also in masses or as needle-like crystals. Composition, manganese dioxide (MnO_2). An ore of manganese; as a coloring in bricks, etc., and various other uses.

25. *Limonite*.

Yellow, brown, or nearly black. Streak, yellowish brown. Luster, silky or submetallic. Usually fibrous in structure; in layers or crusts; rounded, concretionary forms; porous or earthy masses; "iron rust." $H.=5-5.5$. $G.=3.6-4$. Earthy forms easily marking paper. Composition, ferric hydroxide ($2\text{Fe}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$). An important iron ore; as a paint. Differs from hematite in containing water. A resulting product from the decomposition of other minerals containing iron, as residual material or as a desposit from solution. The characteristic material of the "iron hat" of certain ore veins. Called brown hematite.

VARIETIES OF LIMONITE.

a. *Compact*.

Luster, silky to submetallic. Fibrous structure and rounded forms.

b. *Ocherous*.

Yellow or brownish. Often mixed with soil, to which it gives a characteristic color.

c. *Bog Ore*.

Loose, yellowish. Found in marshes.

26. *Bauxite*.

White, yellowish white, brown, or red. Usually in masses of rounded, concretionary particles an eighth

of an inch in diameter and smaller; sometimes earthy. $H.=1-3$. $G.=2.5$. Composition, essentially aluminum hydroxide ($Al_2O_3 \cdot 2H_2O$); is not a true mineral. An ore of aluminum. Occurs in Arkansas; also in Georgia and Alabama.

CARBONATES

27. *Calcite*.

Colorless or white; also tints of blue, red, green, etc.; may be brown or black, when impure. Cleavage, perfect rhombohedral. Transparent to opaque. $H.=3$. $G.=2.71$. Effervesces in acid.

VARIETIES OF CALCITE.

a. Crystals (and fragments of crystals).

Dog-tooth spar; nail-head spar; Iceland spar.

b. Satin Spar.

Fibrous, with a silky luster.

c. Travertine.

Coarsely fibrous or columnar in structure. Formed around springs; the columnar structure, developing normal to the surface of evaporation, is often in layers.

d. Mexican Onyx.

Similar to travertine in origin, but usually a finer structure and a more delicately banded appearance. Used for ornaments, table-tops, etc.

e. Stalactites.

Cylindrical or conical forms suspended from the roofs of caves. Formed by the evaporation of water dripping from the ceiling.

f. Stalagmite.

Material deposited on the floor of caves, from the water dripping from the ceiling.

g. Marble.

Massive, crystalline texture, White, clouded to grayish or bluish, yellowish, brownish. Certain impure forms of limestone containing fossil shells, or having the impurities distri-

buted in an irregular, angular fashion often classed here. Extensively used for interior work in public buildings and offices.

h. Limestone.

In masses or beds. Various colors, usually grayish, bluish, or buff. Usually compact; sometimes crystalline, sometimes showing oolitic or highly fossiliferous structure; other kinds with a considerable amount of impurities, such as clay or silt. More strictly, a rock. A building material, an ingredient of Portland cement, etc.

i. Chalk.

White, yellowish, or grayish. Soft enough to make a mark on a board but usually having some cohesiveness. Useful for Portland cement; also for various other purposes.

j. Marl.

A soft, earthy, whitish material, with or without visible pieces of shells. Useful for Portland cement.

28. *Dolomite.*

White, reddish, or grayish; also green, brown, or black. Resembles calcite, but does not effervesce in cold acid, unless powdered. Effervesces in hot acid. $H.=3.5-4$. $G.=2.8-2.9$. Crystals, commonly curved or saddle-shaped. Cleavage, rhombohedral. Composition, calcium-magnesium carbonate ($CaMgC_2O_6$). For building stone and furnace linings. Occurs extensively; forms the southern Tyrol Alps. Is a secondary rock, having been formed from ordinary limestone by replacement.

29. *Magnesite.*

White or gray; also yellowish or brownish. Commonly massive, compact; sometimes shows cleavage. Fracture, flat conchoidal. Luster, vitreous to dull. Composition, magnesium carbonate ($MgCO_3$). $H.=3.5-4.5$. $G.=3.-3.12$. Used for brick for lining furnaces in steel works; various chemicals, as epsom salts. A secondary mineral; occurs in talc schist, serpentine, etc.

30. *Siderite*.

Brownish, grayish, brownish red; sometimes white. Crystals, rhombohedral, often curved. Cleavage, rhombohedral. $H.=3.5-4$. $G.=3.83-3.88$. Luster, vitreous to pearly. Magnetic after heating. Effervesces slowly in cold acid; readily in hot. Composition, ferrous carbonate ($FeCO_3$). Minor ore of iron.

31. *Smithsonite*.

Greenish, grayish, brown. $H.=5$. $G.=4.30-4.45$. Rounded, crust-like forms, as if deposited from solution around irregular surfaces--called "reniform" or "botryoidal." Composition, zinc carbonate ($ZnCO_3$). An important ore of zinc. Distinguished from calamine by its effervescence in acid. Usually found in the oxidized zone.

32. *Malachite*.

Bright green. Luster, silky or vitreous. Streak, pale green. Commonly encrusting, with fibrous structure. $H.=3.5-4$. $G.=3.9-4.03$. Effervesces in acid. Composition, basic copper carbonate ($CuCO_3 \cdot Cu(OH)_2$). An ore of copper; sometimes as an ornamental stone; as a pigment. Occurs in the oxidized zone.

33. *Azurite*.

Azure blue. Streak, light blue. Luster, vitreous. $H.=3.5-4$. $G.=3.77-3.83$. Effervesces in acid. Composition, basic copper carbonate ($2CuCO_3 \cdot Cu(OH)_2$). An ore of copper. Occurs in the oxidized zone.

SILICATES

FELDSPAR GROUP

34. *Orthoclase*.

Flesh-red, white, colorless, pale yellow. Cleavage, in two directions rectangular. $H.=6$. $G.=2.57$. Not effervescing in acid. Resembles microcline,

which is of a different crystallographic system. Composition, potassium-aluminum silicate (KAlSi_3O_8). Used in the manufacture of porcelain. Occurs in igneous rocks, especially in granites.

35. *Microcline*.

Cream-white to white; also red or green. Cleavage good, in two directions, nearly 90 degrees. Luster vitreous to pearly. H.=6-6.5. G.=2.55. Like orthoclase in composition and occurrence.

36. *Albite*.

White; also bluish, reddish, or gray. Not surely distinguished from other feldspars except optically; certain fine striations appearing on the base of the crystal distinguish this mineral from orthoclase. Resembles barite, but is harder. H.=6-6.5. G.=2.62-2.65. Composition, sodium-aluminum silicate ($\text{NaAlSi}_3\text{O}_8$). Use, same as orthoclase; a variety showing a play of colors on a cleavage surface is used for jewelry, and is called moonstone. Occurs in many igneous rocks; common in pegmatite dikes, associated with tourmaline, lepidolite, etc. Albite is one of the so-called plagioclase feldspars.

FELDSPATHOID GROUP

37. *Leucite*.

White, gray. Usually in form of trapezohedral crystals (tetragonal trisoctahedron.) H.=5.5-6. G.=2.45-2.50. Luster, vitreous. Composition, potassium-aluminum silicate ($\text{K}_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 4\text{SiO}_2$). Occurs in igneous rocks, especially in lavas, taking the place of feldspars. In Vesuvius lavas; Leucite Hills, Wyoming.

38. *Nephelite*.

Gray, white, colorless; also greenish gray or reddish. Luster, greasy to vitreous. Crystals are hexagonal.

H.=5.5-6. G.=2.55-2.65. Composition sodium-aluminum silicate (NaAlSiO_4). Occurs in igneous rocks; associated with leucite. Other names, nepheline, elaeolite.

PYROXENE GROUP

39. *Pyroxene*.

Green of various shades, from nearly white to black, usually dull. H.=5-6. G.=3.2-3.6. Luster, vitreous to resinous. Crystals usually short and thick. Cleavage, nearly at right angles but imperfect.

VARIETIES OF PYROXENE.

a. Augite.

Black, greenish. Usually in short, thick crystals, nearly square or octagonal. H.=5.5. G.=3.3. Composition, a silicate mainly of calcium, magnesium, aluminum, and iron ($\text{CaMgSi}_2\text{O}_6$) mixed with Mg, Fe) $\text{TiFe}_2\text{SiO}_6$. Occurs in basic extrusives.

b. Diopside.

White, gray, or green. Crystals, prismatic, usually four or eight-sided. H.=5.6. G.=3.29. Composition, calcium-magnesium silicate ($\text{CaMgSi}_2\text{O}_6$). Occurs in gabbros and peridotites; also in metamorphic rocks.

AMPHIBOLE GROUP

40. *Hornblende*.

Dark green, dark brown to black. H.=5.5. G.=3.05-3.47. Cleavage, prismatic, forming angles of 56° and 124° , thus distinguishing it from pyroxene. Luster vitreous to silky. Composition, a complex silicate of calcium, magnesium, iron, and aluminum, with fluorine and hydroxyl. Occurs in igneous rocks, such as granites, syenites, diorites, andesites, and some basalts; also in schists and gneisses. Hornblende is one of a large group of minerals and it has numerous varieties.

41. *Tremolite*.

White to dark gray. Fibrous or columnar masses; in crystals, long and bladed or short and thick. Cleavage, of the hornblende habit — in two directions, forming angles of 56° and 124° . H.=5.5 G.=2.9-3.1. Composition, calcium-magnesium silicate ($\text{Ca-Mg}_3\text{Si}_4\text{O}_{12}$). Fibrous forms of tremolite, and of other varieties of amphibole not containing aluminum, are called asbestos. As such, they are useful for making fireproof cloth and other non-combustible articles.

42. *Beryl*.

Tints of green, sometimes white; also light blue, yellow, and pale pink. H.=7.5-8. G.=2.63-2.80. Luster, vitreous. Crystals, six-sided. Composition, beryllium-aluminum silicate ($3\text{BeO}.\text{Al}_2\text{O}_3.6\text{SiO}_2$). A gem stone. In pegmatite veins, in the Black Hills, and in San Diego County, California; in mica schists, and in some sedimentary rocks.

VARIETIES OF BERYL.

a. *Emerald*.

Bright emerald-green. A valuable gem. Occurs near Muzo, Columbia, South America.

b. *Ordinary Beryl*.

Various colors, pale green the most common.

GARNET GROUP

43. *Garnet*.

Red, brown, yellow; also white, apple-green, black. H.=6.5-7.5. G.=3.15-4.3. Luster, vitreous to resinous. Streak, white. Crystals, dodecahedron and trapezohedron common forms; also, these in combination. Composition, various silicates of calcium, magnesium, aluminum, and iron; also of chromium

and manganese. Used as an abrasive; some kinds are used as gems. Occurs in metamorphosed limestone, schists, pegmatites, lavas. etc.

VARIETIES OF GARNET.

a. Almandite.

Deep red to black. Transparent to translucent. $G.=4.25$. Includes precious garnet in part and common garnet in part. Composition, $(FeO.Al_2O_3.3SiO_2)$. Some specimens used as gems.

b. Andradite.

Yellow, green, red, brown, black, in various tints. $G.=3.75$. Composition, $(3CaO.Fe_2O_3.3SiO_2)$. Common garnet.

OLIVINE GROUP

44. *Olivine.*

Yellowish green, olive green; sometimes brownish. $H.=6.5-7$. $G.=3.27-3.37$. Granular masses, usually. Luster, vitreous. Composition, magnesium-iron silicate $(Mg,Fe)_2SiO_4$. Some varieties used as a gem, called peridot. Occurs as an igneous rock; also, as the result of metamorphism of sedimentary rocks. Other names, chrysolite, peridot.

45. *Topaz.*

Colorless, pale yellow, white, bluish, greenish, reddish. $H.=8$. $G.=3.4-3.6$. Cleavage, perfect, parallel to base of crystal. Composition, aluminum fluosilicate $(AlF)_2SiO_4$.; hydroxyl may replace part of the fluorine. A gem stone. Occurs in cavities in granites and rhyolites. In Colorado, Utah, Maine, Mexico, Ural Mts.

46. *Calamine.*

White, colorless; sometimes bluish, greenish or brownish. Cleavage, perfect in one direction. $H.=4.5-5$. $G.=3.40-3.50$. Luster, vitreous. In aggre-

gates or coatings. Composition, zinc silicate ($\text{H}_2\text{O} \cdot 2\text{ZnO} \cdot \text{SiO}_2$). An ore of zinc. Occurs in the oxidized zone, being derived from sphalerite. Associated with smithsonite, which it resembles.

47. *Tourmaline.*

Black; also brown, blue, green, red and pink. Brittle. $\text{H.}=7\text{--}7.5$. $\text{G.}=2.98\text{--}3.20$. In crystals, attached or embedded; also columnar. A cross-section of the crystal three-, six-, or nine-sided; often somewhat rounded. Composition, a complex silicate of boron and aluminum, with iron, magnesium, or the alkalis. The brightly-colored varieties are used as gems. Occurs in pegmatite veins, often associated with beryl, lepidolite, albite, fluorite, quartz, etc. Black Hills; San Diego County, California; Maine; Massachusetts, etc.

VARIETIES OF TOURMALINE.

a. Ordinary.

Black. Associated with muscovite or biotite.

b. Rubelite.

Red to pink. Associated with lepidolite.

48. *Staurolite.*

Brown. $\text{H.}=7\text{--}7.5$. $\text{G.}=3.65\text{--}3.77$. Crystal commonly twinned, producing cross-like forms, whence the name. Composition, iron-aluminum silicate ($\text{H}_2\text{O} \cdot 2\text{FeO} \cdot 5\text{Al}_2\text{O}_3 \cdot 4\text{SiO}_2$). Used as ornament, especially the forms that are a perfect cross. Occurs usually in mica schists, often associated with garnet, tourmaline, etc. In New England states; Georgia; Ducktown, Tenn.; Taos County, New Mexico.

MICA GROUP

49. *Muscovite.*

Colorless, brownish, greenish; rarely reddish. Transparent to translucent. Cleavage, exceptionally per-

fect, in one direction; into thin, elastic sheets. $H.=2\text{--}2.5$. $G.=2.76\text{--}3$. In cleavage masses and in scales. Composition, potassium-aluminum silicate, generally, $(H_2KAl_3(SiO_4)_3)$. Used as an insulator in electrical apparatus; as a lubricant; for stove doors, etc. Occurs widely, in granites, pegmatites, schists, and gneisses. In many places in the Appalachian region; South Dakota; Idaho; New Mexico. Improperly called "isinglass"; also called potash mica.

VARIETIES OF MUSCOVITE.

a. Ordinary Muscovite.

b. Sericite.

Fine silky or scaly masses, often called talc schist; formed by the weathering of feldspars, etc.

50. *Lepidolite.*

Rose-red, violet-gray, lilac, or white. Cleavage, perfect, in one direction. Usually in scaly masses. $H.=2.5\text{--}4$. $G.=2.8\text{--}2.9$. Composition, lithium-potassium-aluminum fluo-silicate $(LiKAl_2(OH,F)(SiO_4)_3)$. A source of lithium. Occurs in pegmatite dikes, associated with spodumene, albite, fluorite, etc., in Taos County, New Mexico; with rubellite, near San Diego, California. Used in making opal glass, etc.

51. *Biotite.*

Black to brown; sometimes green. Opaque to transparent, according to thickness of sheets. Cleavage, exceptionally perfect, and as in muscovite. Luster, pearly to vitreous. $H.=2.5\text{--}3$. $G.=2.7\text{--}3.1$. Composition, $((H,K)_2(Mg,Fe)_2Al_2SiO_4)_3$. Occurs in many igneous rocks, especially in granites, syenites, diorites, rhyolites, etc.; also, in schists and gneisses. On Vesuvius; associated with muscovite in the New England states.

CHLORITE GROUP

52. *Prochlorite*.

Green, of various shades. Cleavage, like mica, but the sheets not elastic. Massive, foliated, or granular forms. Translucent to opaque. $H.=1-2$. $G.=2.78-2.96$. Composition, acid magnesium-aluminum-iron silicate ($H_{40}(Fe,Mg)_{23}Al_{14}Si_{13}O_{90}$). A secondary mineral in igneous and metamorphic rocks, derived from biotite, hornblende, etc.

53. *Clinochlore*.

Green of various shades; also, yellowish and white. Cleavage, very perfect, in one direction; laminae tough but not elastic. $H.=2-2.5$. $G.=2.65-2.78$. Composition, similar to that of prochlorite, but with more silicon and less ferrous iron.

54. *Serpentine*.

Yellowish green, blackish green, olive-green. Luster, oily to waxy. Usually massive; sometimes finely fibrous. $H.=2.5-4$. $G.=2.50-2.65$. Composition, hydrous magnesium silicate ($3MgO.2 Si_2.2H_2O$). Used in interior decoration, as wainscoting, mantels, etc.; the fibrous variety is one kind of asbestos. Occurs always as a secondary product of the alteration of such minerals as olivine, hornblende, pyroxene. Also called serpentine marble. Name derived from the resemblance of the rock to a snake's skin.

VARIETIES OF SERPENTINE.

a. Massive.

Ordinary serpentine, varying shades of color.

b. Chrysotile.

Fibrous, in soft, silky masses filling seams in serpentine rocks. Commercially important as asbestos. The most of the world's production comes from southern Quebec.

c. Serpentine Rock.

Large masses, often mixed with more or less

of calcite or dolomite. Sometimes mottled with red. Ophicalcite, verde antique, serpentine marble, etc.

55. *Talc.*

White, gray or pale apple-green. Feel, soapy. Cleavage, perfect, in one direction. Usually in scaly or foliated masses. $H.=1-1.5$. $G.=2.7-2.8$. Luster, pearly. Composition, acid metasilicate of magnesium ($H_2O.3MgO.4SiO_2$). Coarser varieties used for table tops, sinks, etc.; for pencils; for toilet powders, etc. A stable product of the zone of weathering, being derived from the alteration of magnesium-bearing rocks such as tremolite, etc.

VARIETIES OF TALC.

a. *Foliated.*

Greenish white, or white, usually. Used as filler in paper, toilet powder, etc.

b. *French chalk.*

White, Compact and soft. Used for pencils, tips of gas burners, etc.

c. *Soapstone.*

Gray to greenish. Generally coarsely granular. $H.=1.5-2.5$. Used for sinks, table tops, etc. Known as steatite.

56. *Kaolinite.*

White, yellowish to brownish, etc. Clay-like masses, usually. $H.=2-2.5$. $G.=2.6-2.63$. Usually unctuous and plastic. Composition, hydrous aluminum silicate ($2H_2O.Al_2O_3.2SiO_2$). Used in manufacture of porcelain, china; the basis of most clays, in which form it is used for pottery, brick, etc. Occurs in the zone of weathering, resulting from the decomposition of the feldspars, etc.; in beds or irregular masses. In China, near Jauchau Fu; Delware; Silverton, Colorado, etc.

57. *Bentonite.*

Ivory-colored to white; also red and olive-green.

Luster, dull to earthy. $H.=1$. Absorbs seven times its volume of water. When moistened, swells and collapses. On drying, breaks into roughly rectangular shapes, with a conchoidal fracture. Composition, hydrous aluminum-iron-magnesium silicate. Used to give body and weight in paper manufacture; in antiphlogistite; as a retarder in cement plasters; may be useful in the manufacture of dynamite. Occurs in many places in Wyoming and in New Mexico. (See U. S. G. S. Bulletin 364, P. 58).

PHOSPHATES, BORATES, ETC.

58. *Apatite*.

Sea-green, gray, reddish, brownish, bluish; sometimes white. In crystals of hexagonal form, and massive. $H.=5$. $G.=3.17-3.23$. Luster, vitreous to resinous. Cleavage, imperfect, parallel to base of crystal. Composition, $(3Ca_3P_2O_8.CaF_2)$. Useful as a source of phosphorous in the manufacture of fertilizers. Occurs most commonly in metamorphic rocks, especially in granular limestone; in veins, associated with tin ore, etc.; in small amounts in igneous rocks, in pegmatite dikes. In Norway; Cornwall, England; New England states and various places in the Appalachian region; very extensively in southern Canada. Named apatite on account of the difficulty in identifying the mineral by older mineralogists.

59. *Turquoise*.

Bluish green, sky-blue; becomes paler on exposure. Usually massive, in incrustations. Fracture, conchoidal. $H.=5-6$. $G.=2.6-2.83$. Composition, $(Al_2(OH)_2PO_4.H_2O)$, with some copper, giving the color; a hydrous phosphate of aluminum and copper. Much used as a gem; prepared and set in silver rings and bracelets by the Pueblo Indians. Occurs in brecciated trachyte, in Persia; in andesite, in Los Cerril-

los Mountains, New Mexico; Nev.; Calif., San Bernardino Co.; Ariz.; Colo.; Mexico.

60. *Colemanite*.

Colorless or white. Cleavage, perfect, in one direction. In crystals or granular masses. Luster, adamantine to vitreous. $H.=4-4.5$. $G.=2.42$. Compositions, hydrous calcium borate ($Ca_2B_4O_{11} \cdot 5H_2O$). Source of borax and boric acid. Occurs in shales, near Calico, San Bernardino County, Calif.; abundant near Daggett, in Mojave Desert.

SULPHATES

61. *Barite*.

Colorless, white, yellowish, gray, bluish, reddish, brownish, etc. In crystals, usually flat; also in rounded forms, with radiated or fibrous structure; lamellar; crested; granular; earthy. Cleavage of crystals, perfect, in three directions. $H.=2.5-3.5$. $G.=4.3-4.6$. Transparent to opaque. Composition, barium sulphate ($BaSO_4$). Used in making paint; in the manufacture of barium salts, etc. Occurs in veins, associated with ores of lead and zinc, calcite, etc.; in masses in beds of hematite; in veins in sedimentary rocks; as residual material from the weathering of limestone. One of the heaviest of transparent minerals; the name is derived from a word meaning weight. Called heavy spar, barytes.

62. *Anhydrite*.

White; colorless, grayish, bluish, or reddish. Usually in granular masses; sometimes in cleavable masses. Cleavage, in three directions at right angles. $H.=3-3.5$. $G.=2.9-2.98$. Luster, pearly to vitreous. Does not effervesce in acid. Composition, anhydrous calcium sulphate ($CaSO_4$). Occurs in beds, as the re-

sult of deposition from sea water; associated with rock salt and gypsum; often found with the "red beds."

63. *Gypsum*.

Colorless, white; sometimes yellowish, grayish, or pinkish, on account of impurities. Luster, vitreous, pearly, or silky. Cleavage, eminent, in one direction, into thin, somewhat flexible leaves that are not elastic. Massive varieties do not show cleavage, and fibrous varieties are not representative of the property quickly noticeable in the crystal. $H.=1.5-2$. $G.=2.31-2.33$. Used for making plaster of Paris; wall plaster; as a retarder in Portland cement, etc.; as a fertilizer, to neutralize black alkali; alabaster is carved into ornaments. Occurs in beds, similar to the occurrence of anhydrite, and is a deposit from evaporating inland seas, alternating with limestone and salt. Some beds of gypsum are the result of weathering on anhydrite. Produced sometimes in sedimentary rocks by the oxidation of pyrite and the consequent formation of sulphuric acid, which reacts on the calcium carbonate in the rocks. Is found widely distributed; N. Y.; Mich.; Ohio; Iowa; Va.; Kan.; Okla.; N. Mex.

VARIETIES OF GYPSUM.

a. *Selenite*.

Colorless, transparent crystals or foliated masses.

b. *Satin Spar*.

White, translucent, fibrous masses, having a satiny luster. Splits rather easily.

c. *Alabaster*.

White, translucent, fine-grained masses. Used for carving into ornaments, etc.

d. *Rock Gypsum*.

Dirty white or dull-colored, more or less compact rock, with impurities of clay, etc.

THE DETERMINATION OF ROCKS

The term "rock" is applicable to large and frequently recurring portions of the earth's crust regardless of their mineral content; but most rocks are combinations of two or more minerals, or, if essentially of one mineral, contain certain impurities. Minerals as related to rocks are like the different materials used in building in their relation to the structure as a whole. The individual material may be just concrete, or just steel, or just lumber; as in a rock the individual mineral may be pure quartz, or pure calcite, or pure kaolin. Minerals are called rocks when they occur in very large masses; as, for instance, vein deposits of pure quartz, deposits of pure gypsum, etc.

The scientific study of rocks involves the consideration of their origin, their composition, their place of occurrence, their structure; it takes account of the changes they have undergone subsequent to the operation of the processes that may be said to have produced them; notes their uses, etc. Classified according to origin, we have igneous rocks and sedimentary rocks. A third class appears when we consider certain changes that have taken place in either of the two classes since their first formation. Rocks of the third class are called metamorphic.

Igneous rocks are those that have formed from a cooling magma, or melted mass. They may be at the earth's surface or deep below it. They may have taken their present position as outflows over the surface or by the removal of overlying material through the processes of weathering and erosion.

Sedimentary rocks are formed by the accumulation of fragmental material, or material in solution, that has been derived from the decomposition and disintegration of other rocks or that has come from highly-heated portions of the earth. The accumulation is due to the action of wind and moving water or is dependent on the presence of bodies of water, which favor the assorting and deposition of material.

Sedimentary rocks are usually stratified and often contain the shells or forms of organisms.

Metamorphic rocks are the result of the action of crustal movements, heat, or mineralized solutions on previously-formed rocks at considerable depth from the surface. Sometimes a combination of these agencies has produced the metamorphism. Often the former structure of the rocks is discernible, but usually all evidence of the original condition of the rocks is obliterated.

The properties of rocks that are the most useful in their determination are structure, texture, composition, general hardness, and color. By structure is meant the form and arrangement of the larger features of the rock, as stratification, solidity or porosity, foliation, etc.

Texture refers to the relative fineness or coarseness of grain of the minutest portion of the rock. In igneous and metamorphic rocks this would usually mean the degree or the relative coarseness of the crystallization. Great coarseness generally means very slow cooling of the magma. In sedimentary rocks, texture may refer to the size of the component grains, or to their absence; or to the degree of the crystallization.

By composition is meant the mineral composition rather than the chemical. In coarse-textured rocks the minerals are often discernible.

Rocks do not usually have a certain degree of hardness, as minerals do, and this property can not be relied on precisely. But there is considerable difference between the hardness of sedimentary rocks like limestone or gypsum and most igneous rocks.

The colors of rocks are so variable that they are not to be depended upon without the confirmation of other tests. As a rule the acidic igneous rocks are light-colored, while the basic are dark-colored. Probably most limestones are light-colored and most shales are dark-colored. The weathered surface of a rock has a different color from the freshly-broken surface. The same type of rock may exhibit different colors in different specimens.

GENERAL CLASSIFICATION OF ROCKS

I. MASSIVE AND SOLID

A. TEXTURE GLASSY

Obsidian -----	1	Pitchstone -----	2
Perlite -----	3		

B. TEXTURE DENSE

HARDER THAN 5.

Rhyolite -----	9	Flint -----	20
Andesite -----	10	Jasper -----	21
Basalt -----	11	Novaculite -----	35
Diabase -----	12		

C. TEXTURE DENSE

SOFTER THAN 5.

Limestone -----	30, 31	Serpentine -----	45
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D. TEXTURE GRAINED OR CRYSTALLINE

HARDER THAN 5.

Diabase -----	12	Diorite -----	16
Granite -----	13	Gabbro -----	17
Syenite -----	14	Gneiss -----	37
Monzonite -----	15	Quartzite -----	41

E. TEXTURE GRAINED OR CRYSTALLINE

SOFTER THAN 5.

Rock Salt -----	18	Ophicalcite -----	44
Gypsum -----	19	Serpentine -----	45
Limestone -----	30, 31, 32	Soapstone -----	46
Marble -----	42, 43		

F. TEXTURE PORPHYRITIC

Obsidian -----	1	Basalt -----	11
Pitchstone -----	2	Granite -----	13
Rhyolite -----	9	Syenite -----	14
Andesite -----	10	Monzonite -----	15

II. MASSIVE AND CELLULAR

A. TEXTURE GLASSY

Pumice -----	4
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B. TEXTURE DENSE

Scoria -----	5	Calcareous Tufa -----	24
Basalt -----	11	Buhrstone -----	
Geyselite -----	22		

III. GRANULAR. FRIABLE OR UNCONSOLIDATED

A. TEXTURE GLASSY OR GRAIN FINE

Volcanic Dust	6	Loess	34
Diatomite	23	Clay	(Glossary)
Chalk	26	Silt	(Glossary)
Marl	27		

B. GRAIN MEDIUM, SANDY

Volcanic Dust	6	Sand	
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C. FRAGMENTS OVER 1-8 INCH IN DIAMETER, ROUNDED OR ROUGH

Lapilli	8	Gravel	
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IV. STRATIFIED OR BEDDED. MORE OR LESS CONSOLIDATED

A. TEXTURE FINE OR DENSE

Chert	20	Limestone	30, 31, 32
Diatomite	23	Shale	33
Chalk	26	Novaculite	35
Marl	27		

B. TEXTURE OR GRAIN MEDIUM

Sandstone	36
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C. FRAGMENTS OVER 1-8 INCH DIAMETER, ROUNDED OR ANGULAR

Breccia	7, 37	Conglomerate	37
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V. GRANULAR, MASSIVE TO BEDDED. MORE OR LESS CONSOLIDATED

A. TEXTURE OR GRAIN FINE

Volcanic Dust	6	Marl	27
Diatomite	23	Shale	33
Chalk	26	Loess	34

B. TEXTURE MEDIUM. GRAINS VISIBLE

Volcanic Tuff	7	Oolitic Limestone	29
Marl	27	Sandstone	36

C. FRAGMENTS OVER 1-8 INCH DIAMETER ROUNDED OR ANGULAR

Breccia	7, 37	Conglomerate	37
Coquina	28		

VI. NODULAR. SOMETIMES WITH CONCENTRIC LAYERS; OR RADIATED; OR ENCRUSTED

A. TEXTURE DENSE

Flint ----- 20

B. TEXTURE EARTHY TO COMPACT

Geyserite -----	22	Concretions -----	(Glossary)
Calcareous Tufa -----	24		

VII. FIBROUS, RADIATED, OR COLUMNAR

Satin Spar -----	19, 25	Travertine -----	25
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VIII. BANDS OF COLORS

Mexican Onyx -----	25	Limestone -----	31
Agate -- (See "Quartz" p. 23)		Sandstone -----	36
Jaspilite -----			

IX. ARBORESCENT TO CORALLOID OR LOBED

Geyserite -----	22	Calcareous Tufa -----	24
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X. FOLIATED OR LAMINATED. LAYERS SEPARABLE OR NOT

A. TEXTURE OR GRAIN FINE

Slate -----	40	Schist -----	39
Shale -----	33		

B. TEXTURE MEDIUM; MINERALS DISCERNIBLE

Schist -----	39	Quartzite -----	41
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C. TEXTURE COARSE. STRUCTURE LESS LAMINATED; OFTEN CONTORTED

Gneiss ----- 38

DESCRIPTION OF ROCKS

IGNEOUS ROCKS

1. *Osidian*.

Texture, glassy. Structure, massive, solid; sometimes with spherulites, or with bubble-like cavities; sometimes showing flowage, as if drawn out. Luster, vitreous on fresh fracture. Color, black or brownish

red. Opaque to translucent; sometimes transparent on thin edges. Fracture, conchoidal. Composition, high in silica, low in bases except the alkalis; a natural glass. Formerly used by the Indians for arrow points, etc.; some local use as a road metal. Wide occurrence in the West; Yellowstone National Park, etc.

2. *Pitchstone.*

Texture, glassy. Luster, resinous to vitreous. Structure, massive, solid. Fracture, small conchoidal. Color, yellowish, gray, reddish brown, black. Composition, like obsidian, but with 5 to 10% of water. Occurrence, similar to obsidian; Arran, Scotland; Meissen, Saxony.

3. *Perlite.*

Texture, glassy. Luster, pearly. Structure, many small, concentric fractures, giving an onion-like appearance to parts of the mass; somewhat pearl-like. Composition, similar to obsidian, with 2 to 4% of water. Color, gray to blue-gray.

4. *Pumice.*

Texture, glassy as seen in small fragments. Structure, very porous, so that the stone floats on water. Color, usually white or gray; sometimes yellowish. Composition, similar to obsidian. Used as an abrasive. Occurs in volcanic regions; Lipari Islands, most abundant source; many places in the West.

5. *Scoria.*

Structure, porous or vesicular. Texture, usually dense, as seen in small fragments. Color, black or dark; also reddish. Relatively heavy. Composition, low in silica, high in bases. Occurs widely, as a froth on lava flows.

6. *Volcanic Dust.*

White, finely powdered pumice, having little coher-

ence. Texture, glassy. Structure, fragments of pumice that has been exploded by the steam or gases within as it was being ejected from a volcano; the fragments are sharp or angular. Composition, similar to obsidian. Used as an abrasive; for scouring-soaps, as the "Old Dutch Cleanser"; for cement, etc. Occurs widely in the West; in nearly every county in Nebraska; many places in New Mexico.

7. *Volcanic Tuff.*

White to gray, pink, brown, sometimes darker. Structure, massive; made up of fragments of volcanic materials fused or cemented together; often contains crystals of quartz or other minerals. With larger fragments, the rock is called volcanic breccia. The fragments are of various colors and textures. Occurs in Jemez region, Frijole Canyon, etc., N. Mex.

8. *Lapilli.*

Unconsolidated fragments of volcanic materials, as pieces of pumice, in size like fine gravel. Color, brown or gray. Deposited relatively near the volcano. A good road material. Many places in the West; New Mexico; Arizona, etc.

9. *Rhyolite.*

Texture, dense; usually having a few visible crystals of some hard mineral. Structure, massive, solid; often showing flow lines, which property gives the rock its name. Color, brown of different shades, and grayish. Very hard and tough. Luster, dull. Composition, similar to granite; highly siliceous. Useful for paving blocks, concrete, etc.; too hard to be profitably quarried for building stone. Common in the West; Black Hills; Colo.; Nev.; N. Mex.; also in the Lake Superior region; near Portage, Wis., etc.

10. *Andesite.*

Texture, dense. Structure, massive, solid; some-

times cellular; sometimes porphyritic. Color, usually dark gray. Composition, little or no free quartz abundant hornblende or biotite, and lime-soda feldspar. Of wide occurrence in the West; N. Mex.; Colo.; the Comstock lode, Nev.; Mt. Shasta, etc.; also in western Mexico and South America.

11. *Basalt.*

Texture, dense. Structure, massive, solid; sometimes somewhat porous; often porphyritic; sometimes with cavities filled with minerals deposited subsequently, which form is called amygdaloidal basalt. Color, usually black, or very dark gray. Heavy. Composition, plagioclase feldspar, augite, olivine, and magnetite, chiefly; quartz absent. Widely distributed, extrusive rocks, perhaps the most widely of all igneous rocks; India; Snake River region; Arizona; New Mexico, etc.; also around Lake Superior, of pre-Cambrian age.

12. *Diabase.*

Texture, intermediate between the dense and the typical "grained" rocks, very finely crystalline. Structure, massive, solid. Color, greenish gray to dark gray. Heavy. Composition, much the same as basalt. A good road metal. A dike rock. Occurs widely; many prominent landmarks in the East, as the Palisades on the Hudson, etc.

13. *Granite.*

Texture, grained, the individual minerals large enough to be distinguished easily. Structure, massive, solid; often porphyritic. Color, gray, reddish, pinkish, etc. Composition, quartz, orthoclase feldspar, and mica; both biotite and muscovite are common; hornblende may replace part or all of the mica. The most commonly used igneous rock; for buildings, monuments, etc. Of wide occurrence; Vermont;

Mass.; Appalachian region; Wis.; Minn.; Rocky Mountain region. An intrusive rock.

14. *Syenite*.

Texture, grained, like granite. Structure, massive, solid. Color, gray to white, pinkish, reddish. Composition, orthoclase feldspar and hornblende; some have more mica and less hornblende; plagioclase, apatite, and magnetite present in small amounts; quartz absent. Use, much the same as granite; more easily worked. Occurs in masses like granite; not so common as granite; White Mountains; Little Rock, Ark.; Custer County, Colo.

15. *Mozonite*.

Texture, grained. Structure, massive, solid; often porphyritic. Color, gray, pinkish. Composition, orthoclase and plagioclase feldspar in equal amounts and hornblende; intermediate in composition between syenite and diorite. Abundant in the West. The source of many ore deposits.

16. *Diorite*.

Texture, grained. Structure, massive, solid. Color, dark gray to greenish, or almost black. Composition, hornblende, biotite, and plagioclase feldspar; sometimes with considerable quartz.

17. *Gabbro*.

Texture, grained. Structure, massive, solid. Color, gray to black, greenish. Composition, essentially plagioclase feldspar and pyroxene. Used locally to some extent for buildings. Prominent localities, around Lake Superior, Duluth, etc.

SEDIMENTARY ROCKS

18. *Rock Salt*.

Texture, crystalline. Structure, massive, solid. Color clear, grayish, reddish. Taste, salty. Composition, common salt; sometimes with impurities of oxides of

iron, silt, etc. A source of salt. Of wide occurrence, in beds, associated with gypsum, etc., deposited in inland seas of past geological ages.

19. *Gypsum*.

Texture, crystalline, fine-grained to dense. Structure, massive, solid; sometimes fibrous or foliated. Color, white; sometimes stained by impurities of iron oxides, clay, etc. Composition, pure or nearly pure gypsum. Uses, (See No. 63 in "Description of Minerals").

20. *Flint*.

Texture, dense. Structure, nodular; also in layers interbedded with limestone; also in rough, irregular bodies within masses of limestone. Hardness, 7. Fracture, conchoidal. Luster, dull. Occurs in chalk beds, as nodules. Color, black to grayish or white. Composition, nearly pure silica. Occurs in many parts of the world, associated with carbonates of iron or of lime; the iron ores of the Lake Superior region have developed from the "cherty iron carbonates" of pre-Cambrian rocks. Other names practically synonymous are chert and hornstone.

21. *Jasper*.

Texture, dense. Structure, massive, solid. Color, red, yellow, etc. Hardness, 7. Luster, dull. Composition, silica, with oxides of iron in small amount. Associated with iron ores in the Lake Superior region.

22. *Geyserite*.

Texture, compact. Structure, spongy or solid; cauliflower-like, tuberoid. An encrustation, formed around hot springs and geysers.

23. *Diatomite*.

Texture, fine, gritty. Structure, bedded or massive, porous to earthy, friable. White. Light weight.

Composition, mainly hydrous silica and alumina; the microscopic shells of diatoms, with certain impurities. Used as an abrasive; for packing steam pipes, etc. Occurs in thick deposits, in Santa Barbara County, Calif.; near Reno and Goldfield, Nev., etc. Called diatomaceous earth.

24. *Calcareous Tufa.*

Structure, crust-like, coralloid, or arborescent; rounded or cauliflower-like forms. White to yellowish or grayish. Hardness about 3. Effervesces in acid. Composition, mainly calcium carbonate. A deposit from springs, especially those flowing from limestone rocks.

25. *Travertine.*

Structure, fibrous or splintery. Yellowish. Hardness, 3. Effervesces in acid. Composition, calcium carbonate. A deposit in limestone caves. Mexican onyx is a similar deposit having a beautifully-banded structure. Mexican Onyx is used for interior decoration, table tops, ornaments, etc.

26. *Chalk.*

Texture, fine. Structure, massive, friable. White to yellow or grayish. Hardness, not over 3. Effervesces in acid. Composition, essentially calcium carbonate. A deposit formed in the ocean, consisting mainly of the minute shells of foraminifera. Used for crayons, Portland cement, etc. Of wide occurrence; southern United States; Nebr.; S. Dak.; England, the "Cliffs of Dover," etc.

27. *Marl.*

Structure, earthy to friable. Effervesces in acid. White to grayish. Contains fragments of shells, silt, and material secreted by plants growing in shallow lakes; largely calcium carbonate in composition. Useful for the manufacture of Portland cement.

28. *Coquina*.

Structure, a rather loosely-cemented mass of fragments of shells. Occurs on the coast of Florida.

29. *Oolitic Limestone*.

Texture, granular. Structure, massive, solid; formed of small fragments of shells and sand-like grains having a concretionary structure. Effervesces in acid. Nearly pure calcium carbonate. Hardness, 3. White to grayish or cream-colored. An excellent building stone; very extensively used for that purpose throughout the United States. The most productive region is around Bedford, Indiana. Called "Bedford limestone."

30. *Hydraulic Limestone*.

Texture, fine. Structure, massive, solid. Color, gray, bluish to dark gray. Contains impurities of magnesia, silica, and clay, in such proportions that the stone forms a natural hydraulic cement, after burning and grinding.

31. *Ordinary Limestones*.

Textures, variable; coarsely crystalline to very dense. Structure, massive, solid; some kinds, highly fossiliferous; others, with nodules of chert as the most prominent characteristic. Colors, variable; nearly white, grayish, buff, bluish gray, brownish, black, etc. Effervesce in acid. Easily scratched with a knife. Useful for building stones, Portland cement, lime; some varieties are cut and polished for interior decoration, as marble. Widely distributed.

32. *Dolomitic Limestone*.

Resembles some limestones. Is harder, and does not effervesce readily in cold acid. Composition, calcium-magnesium carbonate, with small amount of impurities. A secondary rock, developed from ordinary limestone. Uses, similar to limestone as a building stone; also for furnace linings.

33. *Shale.*

Texture, fine grained to dense. Structure, in thin layers, parallel to the plane of deposition, more or less easily separable. More or less friable, or easily cut. Usually unctuous and plastic when powdered and mixed with water, like clay. Easily weathered, and forms gentle slopes rather than cliffs. Colors, variable; bluish gray to black, yellowish, greenish, white, red to brown, etc. Composition, variable; usually high in alumina; quartz in the form of silt; carbonaceous material, etc.; often with more or less calcite, grading into limestone. Used in manufacture of Portland cement; certain kinds contain hydrocarbons, from which oil may be distilled.

34. *Loess.*

Texture, fine, even-grained. Structure, loose or scarcely coherent; sometimes contains tubular or tubercular concretions; a characteristic feature is its ability to maintain a perpendicular surface for years without caving or slumping. Color, buff or grayish, except where decaying vegetation has given it a darker hue. Composition, mainly quartz; some clay and oxide of iron; also, some calcite. Forms a fertile soil over a large portion of central United States, especially prominent along the Missouri and Mississippi rivers, as bluffs.

35. *Novaculite.*

White. Texture, dense or very fine-grained. Structure, massive, solid. Luster, dull. Hardness, 7. Fracture, conchoidal. General appearance, much like chert, but the fracture-surface is slightly rough to the touch. Composition very fine quartz grains. Used as oilstones, for sharpening tools. Principal occurrence is in Garland and Salina counties, Arkansas.

36. *Sandstone.*

Textures, variable; fine to coarse, rough; porous. Structure, massive to thin-bedded, porous; sometimes showing stratification, crossbedding, etc.; friable to very coherent, according to the amount and kind of cementing material. Hardness, 7. Color, variable; from nearly white to gray, yellowish to red, brown, green etc. Composition, essentially quartz sand cemented by silica, iron oxide, or calcite. An abrasive; used in manufacture of glass; in mortars; as a building stone, etc. Widely distributed.

37. *Conglomerate.*

Structure, massive to bedded, solid; a deposit of rounded gravel and pebbles, cemented into a coherent mass. Color, variable, according to the materials making up the mass or of the cementing material; gray, reddish, spotted, etc. Composition, more variable than sandstone, but most commonly a collection of the harder kinds of materials. Called also "pudding stone." Breccia is similar, but the different ingredients are angular instead of being rounded.

*METAMORPHIC ROCKS*38. *Gneiss.*

Texture, coarse-grained. Structure, massive, solid, laminated to a certain extent; in bands or layers consisting of alternating quartz and feldspar, and some darker mineral, as hornblende or biotite. Color, light gray to dark; more or less streaked or banded; often much contorted or crumpled. Composition, much like granite. Derived from a granite or a sedimentary rock.

39. *Schist.*

Texture, fine-grained to rather coarse. Structure, foliated, separable into moderately thin leaves having a more or less wavy form, or into flaky particles all

oriented in the same direction. Color, variable; gray, green, white, black, Composition, variable; feldspar usually absent; nearly pure minerals form the respective types,—talc schist, hornblende schist, mica schist, chlorite schist, etc.; quartz often present with the different types, and is itself the main constituent in quartz schist; garnet is often present in mica schist. Schists grade into slates, on the one hand, and into gneisses on the other.

40. *Slate.*

Texture, fine dense. Structure, lamellar, cleaving into thin, flat plates; this cleavage not to be confused with the parting along bedding plane, as in shale. On fresh cleavage surface often appears a faint satiny luster. Hard and resistant to weathering, but may be scratched by a knife. Color, black, green, or reddish. Contains a variety of minerals in very small particles, chiefly quartz, mica, chlorite, and carbonaceous matter. Used for roofing and blackboards.

41. *Quartzite.*

Texture, grained, crystalline. Structure, massive, solid; often showing stratification lines; sometimes showing the original sand grains. Luster, vitreous. Color, pink, purplish, yellowish, gray, etc. Fracture, conchoidal, like quartz. Hardness, 7. Composition, mainly quartz; coloring matter of rock due to impurities. Used for paving blocks. Occurs in eastern United States; Rocky Mountains; Lake Superior region; southeastern South Dakota, etc.

42. *Marble.*

Texture, grained, crystalline. Structure, massive, solid, not laminated or stratified; often possesses a clouded or marble appearance, on account of metamorphism undergone. Color, white, gray, yellow,

red, brown, bluish, etc.; clouded, streaked, or blotched. Hardness, 3. Composition, carbonate of lime, with frequent impurities. Fossils absent. Important building stone, especially for interior finish; monuments; statuary. Called crystalline limestone. Found in regions that have been much folded; Vermont; Mass.; N. Y.; Ga.; Tenn.; Colo.; etc.

43. *Dolomitic Marble.*

Texture, crystalline, as in calcite marble. Appearance, much the same as calcite marble. Hardness, a little greater than calcite. Does not effervesce in cold acid. Composition, dolomite, with various silicate minerals developed from former impurities in sedimentary rock. Use, buildings; statuary; etc. Occurs in Tyrolese Alps; Vermont, etc.

44. *Ophicalcite.*

Texture, crystalline to dense. Structure, solid irregularly intermixed masses of serpentine and calcite or dolomite. Color, mottled green and white. Used for interior decoration. Occurs in Canada; N. Y., etc.

45. *Serpentine.*

Texture dense to grained. Structure, solid, massive. Color, green of several shades, yellowish, brownish. Luster, greasy or waxy. Composition, mainly serpentine, but often with impurities. Used for interior decoration. Occurs on Staten Island; the Pacific Coast ranges; Quebec, etc.

46. *Soapstone.*

Texture, coarse-grained. Structure, solid, massive. Color, grayish green, brownish gray. Hardness, 1-2.5. Composition, mainly talc. Used for laboratory tables, sinks, etc. Produced in N. Y.; Va.; Vt.

GLOSSARY

A

ACID. A compound of hydrogen (or the radical OH) with a non-metallic element (as chlorine, sulphur, etc.), or with a group of elements called a radical. Example, HCl (hydrochloric acid). Acids in general have a sour taste and turn blue litmus red.

ACIDIC. A term describing an igneous rock containing much silica — more than 65%.

AGGLOMERATE. A rock composed of coarse, broken fragments of volcanic rocks cemented together.

AMYGDALOIDAL. Containig lens-shaped cavities, which may be filled with a mineral deposited after, or toward the close of, the cooling of the lava.

ANHYDROUS. Without water in its composition.

ARKOSE. A sandstone containing many fragments of feldspar.

B

BASE. A compound of a metal with the radical OH, as potassium hydroxide, etc. Strong bases are called alkalies, and turn red litmus blue. $\text{Fe}(\text{OH})_3$ is a weak base.

BASIC. A term describing igneous rocks containing less than 55% of silica. Such rocks are generally high in magnesium and iron.

BED. A small division of a stratified series of rocks.

BATHOLITH. An intrusive rock mass, miles in extent, exposed by erosion or uplift.

C

CARBONATE. A compound of a metal with carbon and oxygen, as calcium carbonate (calcite), zinc carbonate (smithsonite), etc. Carbonates may be regarded as salts of carbonic acid.

CLAY. Very fine aluminous material, of great plasticity, varying in hardness but usually easily distintegrating in water.

CLEAVAGE. A property of some minerals by which they tend to break along a plane, or planes, rather than irregularly. The property persists, no matter how small the particle. A similar property is possessed by some rocks (slaty cleavage), which is due to other causes.

COMPOUND. A chemical combination of two or more elements.

CONCHOIDAL. Shell-like; applied to fracture. Glass breaks with a conchoidal fracture.

CONCRETION. Spherical, cylindrical, or irregular masses formed in sedimentary rocks by the deposition of mineral matter around a center. The deposited material may be of some mineral alone or it may include and cement a portion of the enclosing rock.

CROSS-PEDDING. A structure of sandstones, in which the subordinate layers are inclined to the general plane of stratification.

CRYSTAL. A solid of definite molecular structure, formed through the action of intermolecular forces, and having a regular shape with plane surfaces.

CRYSTALLINE. Having the structure of a crystal or part of a crystal, or of an aggregate of these.

CRYSTALLIZED. Having passed from a solution, or a vapor, to a crystalline solid.

D

DENSE. A condition of texture midway between "glassy" and "grained"; not perceptibly crystalline; having a dull luster on a freshly fractured surface.

DIKE. An intrusion of igneous rock in other rocks, usually vertical in position; in thickness, varying from a fraction of an inch to several rods.

E

EFFERVESCE. To dissolve with bubbling, due to the evolution of gas.

EROSION. The "gnawing away" of a rock by wind or water.

F

FAULT. A fracturing and displacement of a portion of a bed of rock, in which the movement has occurred parallel to the plane of fracture.

FELSITE. A group of extrusive igneous rocks dense in texture and high in silica. Rhyolite is an example.

FIBROUS. Having a wood-like structure, the fibers being either parallel or radiating.

FLOW-STRUCTURE. A characteristic of some volcanic rocks, as rhyolite, appearing as streaks of different colors or different porosity, indicating a flow movement in the melted mass. Is more noticeable on a weathered surface.

FOLIATED. In thin, separable leaves or bands.

FORMATION. A large, well defined, and persistent series or rocks, usually sedimentary.

G

GANGUE. Rocks or non-metallic minerals associated with an ore, and which are frequently removed with the ore.

GEODE. A hollow, rounded rock lined with crystals or layers of chalcedony.

GLASSY. Having the appearance of glass; a term descriptive of a certain texture of igneous rocks, in which crystallization has made little or no progress.

GNEISSIC. Like a gneiss is structure.

GRAINED. A type of texture having crystalline particles large enough to be noticed; like granite.

GRANULAR. In grains, as of sand; not necessarily crystalline.

GRAVITY. Specific gravity; the ratio of the weight of a given volume of a substance to an equal volume of water; indicated in the tables by "G".

GUMBO. A very sticky soil, residual from certain Cretaceous shales, or deposited in river bottoms.

H

HALOID. A compound of a metal with one of the halogen elements, chlorine, fluorine, etc.,—as sodium chloride (common salt).

HARDNESS. The degree of resistance to abrasion; indicated in the tables by "H".

HARD-PAN. A layer of soil hard and resistant, occurring a short distance below the surface. Also a kind of boulder clay difficult to dig with a spade.

HYDRATION. The chemical combination of water with another mineral.

HYDROUS. Containing water in chemical combination.

I

IGNEOUS. Derived from fused material in the earth.

J

JOINT. A crack or crevice in a rock, often so narrow as not to be noticeable.

L

LUSTER. The appearance of light reflected from a surface; as vitreous, resinous, etc.

M

MAGMA. Igneous rock that has not been solidified.

MASSIVE. In large, homogeneous masses, with no indication of bedding.

METAMORPHISM. A change in the mineral content of a rock and a rearrangement of its structure, mainly as the result of excessive heat, the presence of water, and of crustal movements.

MINERAL. A homogeneous substance of definite chemical composition, naturally occurring, and of inorganic origin.

MINERALIZERS. Active gases and vapors dissolved in a magma, that aid in the formation of certain minerals.

N

NATIVE ELEMENT. A mineral composed of a single element, as the metal copper, sulphur, etc.

O

OOLITIC. Like fish eggs; in small round grains having a layer-like structure.

OPAQUE. Not allowing light to pass through.

ORE. A mineral, usually metal-bearing, occurring in a deposit sufficiently rich to be profitably mined.

OXIDATION. The process of combining with oxygen, resulting in the simplification and stabilization of matter under atmospheric conditions.

OXIDE. A compound of oxygen with another element, as oxide of iron (hematite), silicon dioxide (quartz), etc.

OXIDIZED ZONE. The portion of the earth's crust in which oxidation acts; practically coincident with the zone of weathering.

P

PEGMATITE. Coarse crystal aggregates resembling granite in composition, but with many accessory minerals such as tourmaline, beryl, etc., occurring in veins or dikes in igneous or metamorphic rocks.

PLAGIOCLASE. A group of feldspars in which the two cleavages form an angle of 85° to 86° instead of 90° as in orthoclase. Labradorite and albite belong to this group.

POROUS. Containing minute openings, as the interstices in sandstone.

PORPHYRITIC. Having conspicuous crystals embedded in a finer-textured mass, which may be glassy, dense, or grained.

PRIMARY. The original condition of a deposit as it was laid down.

R

REPLACEMENT. The process of interchange whereby one mineral is dissolved and carried away while another occupies its place.

S

SALT. A compound resulting from the reaction (actual or hypothetical) of an acid upon a base, as the formation of sodium chloride by the reaction of hydrochloric acid upon sodium hydroxide.

SCHISTOSE. A structure possessed by some rocks that have suffered great pressure and heat, until the mineral particles are flattened or are oriented with their cleavage planes parallel, so that the rock breaks easily along those planes.

SCORIACEOUS. Full of small holes. Applicable to some basaltic lavas.

SECONDARY. A term descriptive of deposits that have resulted from the alteration of primary deposits by decomposition, replacement, or enrichment by leaching.

SECTILE. Capable of being whittled into more or less cohesive shavings.

SEPTARIA. A concretionary mass containing many cracks radiating from the center, that have been filled by deposition from solution. The original material may

weather out, leaving the filled cracks standing out as walls of polygonal cavities.

SILICATE. A compound of a metal with silicon and oxygen, as zinc silicate (willemite), potassium-aluminum silicate (orthoclase), etc. Silicates may be considered as salts of a silicic acid.

SILT. Sediment finer than very fine sand.

SLATY. Having a structure like slate.

SLICKENSIDES. Polished surfaces of rocks that have been rubbed together along a fault plane.

SOLID. The quality of being free from cavities.

STRIATIONS. Fine parallel lines on the surface or on cleavage planes of a crystal, or on the surface of a rock.

STRUCTURE. The larger features of a rock and their arrangement.

SULPHATE. A compound of a metal with sulphur and oxygen, as calcium sulphate (anhydrite), etc. Sulphates may be considered as salts of sulphuric acid.

SULPHIDE. A compound of a metal with sulphur alone, as sulphide of iron (pyrite), etc. May be considered as a derivative of the acid H_2S .

T

TILL. Unassorted deposit of a glacier; boulder clay.

TRANSLUCENT. Allowing light to pass through but not permitting objects to be seen.

TRANSPARENT. Clear, so that objects are visible through the substance.

TUFA. Cellular calcareous deposits formed around springs,

TUFF. Small fragments of pumice, volcanic dust, etc., somewhat consolidated.

V

VEIN. A deposit formed in a crevice or seam in rocks, precipitated from solution.

VESICULAR. Having many rounded holes, formed by the expansion of steam and other gases in a cooling lava.

VITREOUS. Glassy; having the luster of glass.

VOLCANIC BOMBS. Masses of lava thrown out from a volcano, that have solidified before falling to the ground.

VOLCANIC NECK. The solidified material of a volcanic vent, now exposed by erosion.

Z

ZONE OF WEATHERING. The part of the earth's crust lying generally between the surface and groundwater level.

